Scoring Methods to Enable Bespoke Portfolio Management

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***Abstract*— To achieve competitive advantage, many companies need to engage and invest in Research and Development. For this investment to be effective, resources need to be allocated appropriately across all projects. However, when the portfolio of the company is diverse or large, this assignment can be challenging. Portfolio Management has been created as a method for companies to effectively manage new, existing and potential projects. Yet, these methods can introduce bias and subjectivity without being flexible to the pieces of information, or attributes that are important to the company. This work adds to the field by proposing three scoring methods that convert any attribute into a numerical representation that can then be used for comparison. For managers, it means that they can select any attributes of importance to them to allow their portfolio to be prioritised and have the resource allocated appropriately to the projects that offer the greatest promise.**

Keywords- Portfolio Management; New Product Development; Scoring; Prioritisation

I. INTRODUCTION

Businesses often form their strategy around the development of new products [1]. This can take several forms including radical [2], incremental [1] and disruptive [3]. These different strategies lead to a number of products making up the company's portfolio [4]. The difficulty for companies comes from selecting which of the next generation of potential developments should become reality and join the existing portfolio [5].

Currently there are a number of tools available to companies to aid this selection process including those presented in [6]–[8]. However, these methods introduce the potential for subjectivity, bias and an undue focus on particular attributes such as those defined by monetary values, when others may be of greater use to the company. This research and paper focus on proposing three new methods to evaluate potential development projects that can be combined to form key elements of a Portfolio Management process.

During the process of identifying new development projects, capturing and understanding information is critical. Therefore, identifying the information which is most critical makes up a core part of this process. Utilising a process of identification from a company's perspective as to which are the most critical pieces of information can allow for directed capture and review. This forms a simple process, especially from the small and medium sized enterprise perspective of limited resource [1], which can result in clear understanding via prioritisation of the options available to them.

From this point, the paper takes the following structure. In Section 2, the background literature on the topic will be investigated including Portfolio Management and the tools that make up these methods. Next, in Section 3, the proposed three methods will be presented along with how they can be combined into a single process. Examples will make up part of these descriptions. Finally, in Section 4, the presented methods and process will be discussed before concluding.

II. BACKGROUND LITERATURE

Many firms rely on Research and Development (R&D) to achieve a competitive position within their market [2]. The challenge associated with this is assessing these opportunities [3] so the available resources can be distributed appropriately to ensure the selected projects can begin and continue. With limited resources, which is always a concern, effectively managing the development pipeline is critical [4]. This helps to maximise returns by only allowing appropriate projects to begin. Within business, this distribution of resource is a managerial decision [5]. As such, the decision requires the necessary attention being placed on planning and understanding projects.

It is not uncommon for several options to present themselves at the same time or to be implemented together [5] alongside existing projects. However, the difficulty with initiating new projects originates from not knowing which

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will be a success [3]. So the question becomes " how to do the correct projects?" [2]. One approach is to use a conceptual funnel [6] which narrows down all potential projects into those with a higher chance of success. Within this conceptual funnel, activities such as investigation, evaluation and prioritising of potential projects are conducted [4]. By prioritising potential projects as part of the conceptual funnel allows for an appropriate distribution of resources [2] to those projects that warrant them more. Approaches that are used to do this are either quantitative or qualitative using methods that range from rigorous tests to social-science methods [3].

A prominent approach to aid in the management of active and potential projects is Portfolio Management [7]. This has been developed to coordinate multiple projects towards the same strategic goals [8] and is commonly used to manage the composition of a company's product portfolio, including potential new product development [7]. This is commonly used in a planning capacity by managers or key players in an organisation [7] and ties into the management of the development pipeline [4]. As a part of this process, a primary filter can be used to draw attention to particular potential projects [9] based on attributes such as their market potential. This can aid in removing those potential projects that would not deliver on their promise or are only pitched due to internal political reasons [2]. Portfolio Management is a way in which information about potential projects is gathered and prioritised [7] such that only the most worthy are chosen to become part of the company's product portfolio.

There are several methods and frameworks discussed in literature for Portfolio Management. A method presented in [9] utilises scoring a potential project with respect to a number of criteria. However, when these same criteria are given to multiple people for review there is the strong possibility for different results to be returned due to their individual experience, making this highly subjective. The risk-reward matrix is also presented in [9] with the most desirable case being to have a project that is both low risk and high reward. Other methods include the organisation wide selection process in [10], the data envelopment analysis and balance scorecard method in [11]. Additional methods are also presented in [2], [3], [12].

When using the presented methods, decision attributes that are commonly used are cost-benefit and cash-flow [12]. These are converted into a single determinant, such as Net Present Value (NPV) or Internal Rate of Return (IRR) [2] so that they can be readily compared. However, there are several attributes that are unable to be converted into a financial measure. These include risk, route to market and engagement opportunities; all critical aspects to understand in relation to a potential technology development. Therefore, by using only financial measures, only half the picture is seen [13]; whereas by using other attributes a more holistic view is attained. Conventionally it is not possible to represent certain attributes using a single financial measure as they are not an amount of money as they are more conceptual; furthermore they can be highly subjective.

III. PROPOSED SCORING METHOD AND PORTFOLIO MANAGEMENT PROCESS

Scoring has been a project selection technique since its origin in the 1950's [9]. Scoring methods help to estimate how attractive a project is and which path to take [14]. In addition, these methods present sufficient rigor while not being overly complex to discourage use [9]. Furthermore, they can also accommodate non-quantitative or "fuzzy" and non-detailed data whilst also being customised for the organisation they are deployed in [9].

To construct the proposed scoring methods, three key properties were identified to differentiate between types of attribute and therefore which method can be used to apply a score. These properties are Independent, Comparable and Bounded. Independent refers to the ability of an attribute to be scored in isolation, with the score it receives being in no way related to those before or relying on those from another attribute. Comparable means that the only way to effectively score an attribute is through comparing it to several other instances. Bounded relates to the possible inputs that can be associated to that attribute, which can be of any value but will always be between two points, i.e., maximum and minimum.

TABLE I. POSSIBLE PROPERTY COMBINATIONS

Combination	Independent (I)	Comparable (C)	Bounded (B)
1	Y	Y	Y
2	Y	Y	N
3	Y	N	Y
4	Y	N	N
5	N	Y	Y
6	N	N	Y
7	N	Y	N
8	N	N	N

Not all the combinations described in TABLE I are possible to be applied together. Combination 1 cannot occur due to attributes not being able to be both Independent and Comparable together as these properties do not align. Combination 2 and 4 are not possible as an Independent parameter, that is also non Bounded, would effectively change each time it is used and would therefore require older versions to be changed, making it none Independent. Finally, combination 6 and 8 are not possible as an attribute can be neither Independent nor Comparable, as they have to be mutually exclusive. This leaves combinations 3, 5 and 7. Each of these combinations derives to make a viable method of applying a score to attributes.

TABLE II. SCORING METHODS BASED ON PROPERTY COMBINATIONS

Method	Combination	I	C	B
Absolute	3	Y	N	Y
Balance	7	N	Y	N
Comparative	5	N	Y	Y

Each of the methods shown in TABLE II will now be presented along with an example demonstrating their use.

A. *Absolute*

This method is the most straight forward of all those proposed and is to be used with attributes that can be used in isolation, i.e., have no direct bearing on others. Furthermore, they can use a simple grading method with a series of criteria and associated scores where the user selects the one which matches the closest. Once the score is applied, it stands irrespective of other attributes, whether they are new or existing.

Associated with each of these criteria is a Normalised Score on the scale desired, 1 – 5 for example. Therefore, by selecting the criteria that best fits with the current attribute, a score is applied. Each criterion then becomes the Normalised Score that can be applied to the attributes.

The steps for this method can be summarised as follows:

1. Define question
2. Define range of responses
3. Select answer from responses
4. Value associated with response assigned as the score

1) *Absolute example*

An example for a use of the Absolute method is the number of geographical regions that a new product could enter. This could be a range between 1 – 6 for how many regions out of Europe, North America, South America, Africa, Asia and Australasia a new product could be marketed in. Such an example is similarly demonstrated in [14] who discuss the effective commercialisation required when selecting appropriate markets for a new product. Therefore by implementing this metric, they would be more certain of a technology to succeed in multiple markets, demonstrating its worth over others. An example of this could be as follows:

"How many regions out of Europe, North America, South America, Africa, Asia and Australasia can the new technology enter?"

1	2	3	4	5	6

Figure 1. Example regions to enter

In this case, the number of regions which the innovation could enter, selected via Figure 1, can be directly related to the score that is applied; with the more regions that can be entered reflecting the higher the absolute score.

B. *Balance*

The Balance method makes use of a Normalised Scale; this is represented by a number scale which is defined by the user and is the range of values that the resulting scores can take. An example would range between 1 and 5 with increments of 1; meaning the scale has five possible values that scored attributes can take. These points on the Normalised Scale then become the Normalised Scores assigned to the attributes.

This method is one which is utilised when the attributes are unable to be scored independently and have to be compared to all values entered previously; an example of this could be the expected return from a product whereby a new market entry has the potential to be far more lucrative than current markets. Therefore to utilise this method, a value for the new attribute is entered by the user, and a comparison is then made between it and existing values. As the new values are unbounded, i.e., can be of any size, attention needs to be placed on their magnitude such that the values that are significantly larger or smaller are normalised.

The balance is defined between two values with set increments between the Normalised Score marks. In all cases with this method, once there are sufficient values (more than one), the upper and lower bound values (5 and 50 for example) are placed in either extreme on the scale as demonstrated in Figure 2.

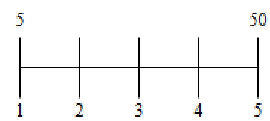

Figure 2. Balance method Normalised Scale

Following this, for any subsequent values entered a series of steps are to be followed to allow for the new value to be placed accordingly. With the upper and lower bounds defined, the difference between them is calculated and divided by the number of steps between them. This Step Change value is added onto the lower bound accumulatively for each step until the upper bound is reached, as shown in Figure 3. These new step values represent what each attribute has to exceed to achieve a certain Normalised Score.

$$Step\ Change = \frac{(50 - 5)}{4} = 11.5 \quad (1)$$

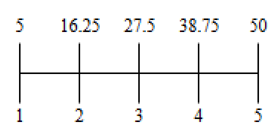

Figure 3. Distributed Step Change value onto Normalised Scale

With the upper and lower bounds set and the Step Change applied to each point on the Normalised Scale, any values entered between these points now fall onto this scale. For example, if a new value was added of 20, this would fit in between 2 and 3 on the Normalised Scale, rounding its Normalised Score down to 2.

The advantage of using this method for such values is that it can cater for any value to be added of any size. These values are then distributed such that the resulting Normalised Score reflects their magnitude. Additionally, if a new value is added of significantly different size, either larger or smaller, the distribution of values is adjusted to reflect this. An example would be where a new value is added, which is significantly smaller, all values are re-distributed up the scale and likewise if a value is entered of significantly larger size, they are re-distributed down the scale. A way to think of this method is by picturing a seesaw; when something with a much larger weight is added (larger value), it tilts in that direction (positive or negative) with respect to the difference in weight (size of value) to that already on it.

The process for this method is:

1. Define range
2. Define increments
3. Calculate result
4. Enter result
5. Assign values automatically if insufficient
6. Or Else, assign minimum and maximum values
7. Calculate Step Change
8. Calculate Normalised Scores
9. Store results

1) Balance example

An example for the Balance method is scoring costs as these values are unbounded and can take any size. For example, if common values are between £10 and £100, but a new value is added of £200, the magnitude of the difference needs to be reflected. In business it is common to conduct investigations into potential developments before conducting any further work into them, such as in the automotive example presented in [15]; whereby they analyse the costs of new automotive products before selecting a development path. This can be combined with that presented in [16], where estimating the cost of a new development before conducting any work, illustrates effective portfolio management.

For example, a user is generating scores based on estimates for market size for a potential technology they could make. Through a simple calculation, approximate values for this can be calculated and entered into the Balance scoring method. Assume that £1m, £2m, £3m, £4m and £5m have already been entered as shown in Figure 4.

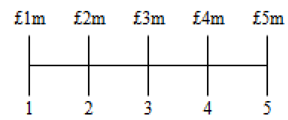

Figure 4. Example Balanced method scale

a. **Entered values are shown on the top, with Normalised Scores on the bottom**

However, if there is a new potential technology that can be made which has a potential market of £10m; this is significantly higher than those already entered. By adding a value of £10m to those already scored, the distribution and the required score to reach the next score boundary changes. This new distribution and assigned scores are shown in Figure 5.

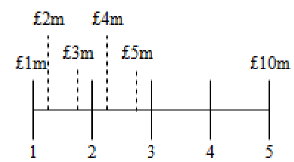

Figure 5. Expanded example of Balance method scale

Figure 5 demonstrates how the addition of a 6^{th}, much larger value onto the scale results in existing values having to shift downwards to accommodate it.

As can be seen, through the addition of unbounded scoring values such as cost or value, there can be a relative shift in the resulting score based on its magnitude. This can be beneficial, as the relative difference is important to demonstrate an attributes worth over the others.

C. Comparative

The Comparative method also makes use of a Normalised Scale and is used when an attribute cannot be treated in isolation. Furthermore, it is designed to be used with those attributes that are more abstract or “fuzzy” and therefore difficult to score directly and instead are scored by comparing them to others. To allow an attribute of this type to be graded, a simple comparison is conducted between several attributes. Those to be used in the comparison are selected to represent a spread of scores such that it can be conducted against all levels of result, not just a single point. The spread of the comparable attributes is determined by the range of the final normalised range of scores to represent the extremes and several intervals in between. In total four existing attributes are selected to be used for the comparison so that when combined with the new attribute, there is a total of five. If there are insufficient existing attributes to facilitate this number for the comparison, select as many as are available and in the case of one attribute assign the middle Normalised Score. The selected attributes, along with that to be scored, are arranged so a pairwise comparison can be conducted so that all attributes are compared to each other. The underlying method that conducts the pairwise comparison is the Analytic Hierarchy

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Process [17]–[19], which uses a four point scale around a midpoint towards each attribute being compared. This demonstrates a graded preference to neither or one of the attributes. Following the completion of the comparisons, a maximum score of 1 is given when all five attributes are selected, and a score for each attribute is calculated. These new scores then update those held for each attribute, as they have been compared to a new attribute and thus their former calculated score is no longer valid. A method for conducting this pairwise comparison is shown in Figure 6, which utilises Microsoft Excel to present the required information to the user.

Current score												Current score	Score
	T5	-9	-7	-5	-3	1	3	5	7	9	T1	5	1
	T5	-9	-7	-5	-3	1	3	5	7	9	T2	4	1
	T5	-9	-7	-5	-3	1	3	5	7	9	T3	2	1
	T5	-9	-7	-5	-3	1	3	5	7	9	T4	1	1
5	T1	-9	-7	-5	-3	1	3	5	7	9	T2	4	1
5	T1	-9	-7	-5	-3	1	3	5	7	9	T3	2	1
5	T1	-9	-7	-5	-3	1	3	5	7	9	T4	1	1
4	T2	-9	-7	-5	-3	1	3	5	7	9	T3	2	1
4	T2	-9	-7	-5	-3	1	3	5	7	9	T4	1	1
2	T3	-9	-7	-5	-3	1	3	5	7	9	T4	1	1

Figure 6. Example Comparison between attributes shown in Microsoft Excel

a. Technology abbreviated to T

Result	
Technology 1	0.2
Technology 2	0.2
Technology 3	0.2
Technology 4	0.2
Technology 5	0.2

Figure 7. Results from attribute comparison shown in Microsoft Excel

Now that the new Analytic Hierarchy Process scores have been calculated relative to the newly added attribute as per Figure 7, the ranking for all attributes and the final Normalised Scale will be changed. To do this a Normalised Scale is used that acts with bounded upper and lower values and an even distribution in between where the user defines the overall size of the scale and the increments between the steps i.e., 1-5 and with a spacing of 1. This method assigns values by initially (when there are insufficient values to occupy all spaces) entering them ranked around the centre of the scale until all spaces are occupied. Following this, the upper and lower bounds are positioned and the remaining values are evenly distributed between these positions, with the space they fall into always being rounded down to the lower bound to award the Normalised Score.

This method of applying scores via an even distribution of values between two extremes is done due to the way the values being entered are bounded between 0 and 1 from the Analytic Hierarchy Process.

The outline for this method is:

1. Define range
2. Define increments
3. Select other paths to compare to
4. Conduct comparison
5. Calculate Analytic Hierarchy Process score
6. Update results
7. Evenly distribute on Normalised Score
8. Update Normalised Scores

1) Comparative example

An example of an attribute that would require the Comparative method would be the risk in relation to developing a new technology. This type of attribute is something that is "fuzzy" and that is difficult to define explicitly in isolation and is therefore easier to compare to others. Such a comparison is presented by [20], [21] for exactly this purpose; risk is a difficult attribute to define, therefore it is best done through a comparison with others. By directly comparing multiple examples of the same attribute, a gauge of the risk can be created.

In this example, the risk associated with creating a new technology (T5) is to be compared with those already analysed, with the question for this comparison being "In each comparison, which technologies development presents the most risk?"

Current score												Current score	Score
	T5	-9	-7	-5	-3	1	3	5	7	9	T1	5	-9
	T5	-9	-7	-5	-3	1	3	5	7	9	T2	4	-5
	T5	-9	-7	-5	-3	1	3	5	7	9	T3	2	3
	T5	-9	-7	-5	-3	1	3	5	7	9	T4	1	1
5	T1	-9	-7	-5	-3	1	3	5	7	9	T2	4	-7
5	T1	-9	-7	-5	-3	1	3	5	7	9	T3	2	7
5	T1	-9	-7	-5	-3	1	3	5	7	9	T4	1	3
4	T2	-9	-7	-5	-3	1	3	5	7	9	T3	2	5
4	T2	-9	-7	-5	-3	1	3	5	7	9	T4	1	-3
2	T3	-9	-7	-5	-3	1	3	5	7	9	T4	1	-3

Figure 8. Example comparison of development risk shown in Microsoft Excel

a. Technology abbreviated to T

In Figure 8, it can be seen how the risk in the development of each technology has been compared. With the results from these comparisons, a calculation is done automatically to create the Analytic Hierarchy Process score for each technology being compared.

Result	
Technology 3	0.344428
Technology 5	0.22468
Technology 4	0.189694
Technology 2	0.124421
Technology 1	0.116777

Figure 9. Analytic Hierarchy Process score for Comparative method

With these newly calculated scores, shown in Figure 9, the database containing scores for all technologies is updated to reflect this change to these items. Following this, all values are distributed evenly on a defined Normalised Scale, between 1 and 5 for example, with respect to the largest and smallest values.

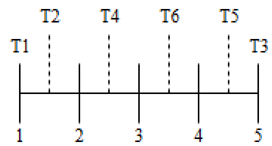

Figure 10. Comparative method scale

a. Technology abbreviated to T

The scale presented in Figure 10 demonstrates how the scores assigned to the technologies are ranked with the use of a Normalised Scale. In this example, an additional technologies score (T6) is also added as this was previously calculated and not selected to be part of the comparison. These scores are distributed with the upper and lower scores first and the remaining scores in order, evenly between these points.

This example shows how the Comparative method can be used to relate a score that can be used as a representation for a "fuzzy" concept such as the risk associated with a concept such as a new technologies development. Therefore, this effectively removed the difficulty in assigning a score to represent an attribute that reflects the addition of more values in the future.

D. *Proposed portfolio management process*

Based on the descriptions of the three scoring methods it can be seen how any attribute in relation to a potential development project can be scored to give a numerical value to represent it. Therefore, using these three methods, a process can be designed that can be used by any company to investigate, evaluate and prioritise potential development projects.

During the identification phase, the attributes that are of importance to the company need to be identified. These can typically include cost, value to the user, risk of development, commercial risk, competition and route to market. As the scoring methods all allow for complex attributes to be converted into a numerical form, they can applied to any attribute that is important to consider. By identifying key attributes the investigation process into the potential development can be enhanced and directed.

TABLE II can be used to align these identified attributes to the correct scoring method. Once the alignment to a scoring method has been completed, the questions, responses and Normalised Scales and Scores need to be recorded. Following this, the review is conducted based on the captured information as directed by the selected attributes.

The scores for each attribute, relating to each potential development project, are aggregated to create its total score. These scores can then be directly compared to those relating to other potential development projects, as they have been investigated and scored using the same attributes. One way to conduct this comparison is by ranking the potential development projects by these scores, giving then an R&D priority.

TABLE III. EXAMPLE AGGREGATE SCORES

Potential development project	Aggregate score
Technology 2	27
Technology 4	25
Technology 1	20
Technology 5	14
Technology 3	6

A threshold value can then be used to distribute resources to the potential development projects that display the required level of promise. By using the possible Normalised Scores for each of the attributes, as defined earlier in the process, a threshold value that has to be achieved before resources are allocated can also be defined. For example, if the maximum possible score for a potential development project is 30, the lowest threshold value to be achieved could be set as 20. This would serve as an indication for the managers tasked with Portfolio Management as to which potential development projects can deliver the required investment and resource utilisation confidence before funding them further.

TABLE IV. EXAMPLE AGGREGATE SCORES USING A THRESHOLD

Potential development project	Aggregate score
Technology 2	27
Technology 4	25
Technology 1	20
Technology 5	14
Technology 3	6

As can be seen in TABLE IV, by using a threshold approach gives a clear indication to the potential development projects that can deliver the most confidence of success. The threshold of 20 is shown by the thick horizontal line meaning potential development projects for Technologies 2, 4 and 1 should be allocated resources in that respective order. Technology 5 and 3 do not make the required threshold to be allocated resource.

This overall process of utilising the three scoring methods for Portfolio Management has been named the ABC Threshold approach. This is reflective of the three methods (Absolute, Balance and Comparative) used to investigate, evaluate and prioritise potential development projects with respect to the specific needs and situation of the company with the use of the threshold value.

The ABC threshold approach can be outlined as follows:

1. Identify attributes of importance
2. Align them to the correct scoring method
3. Conduct the review
4. Prioritise them based on the value

5. Apply threshold

The process described here is reflected in Figure 11 which demonstrates the flow between the required stages.

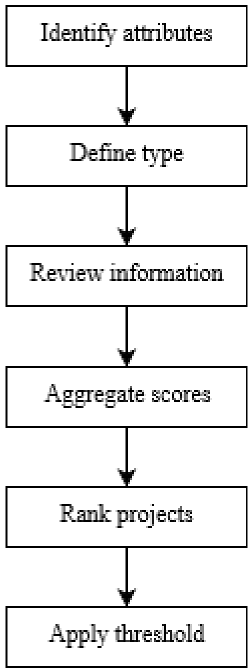

Figure 11. Portfolio Management process stages

The ABC Threshold approach process shown in Figure 11 highlights the simplicity of utilizing this as a method to investigate, evaluate and prioritise a company's portfolio. This is achieved through identification of important information, capturing it, reviewing that which is captured, collecting scores and comparing to a defined threshold to identify the development project to proceed with, if any.

IV. Discussion and Conclusion

The ABC Threshold approach outlined above has several advantages. Firstly, the same attributes from different potential development projects can be directly compared after conversion into a numerical form on the same Normalised Scale. This can deliver an understanding of where certain developments are stronger than others. Secondly, it is very flexible for the company, as any attribute can be scored using the outlined methods. Therefore only the information that is important to the company is analysed. The approach also diminishes the impact of subjectivity on the final score. By defining the review process to be one of three methods, the results found from different points of view should be very similar; meaning the consistent results can be achieved irrespective of who is conducting the review. Bias and personal influence can also be minimised as the final score is not created on the basis of discussion but rather the generation of numerical scores. Finally, the process is reflective of the company's position, as the decision threshold value can be set at the appropriate level. For companies with limited resources, such as small and medium sized enterprises [1], this threshold level can be increased such that potential development projects have to display a higher level of certainty of success before committing to them.

Overall, the ABC Threshold approach can be thought of as a structured investigation, evaluation and prioritisation tool.

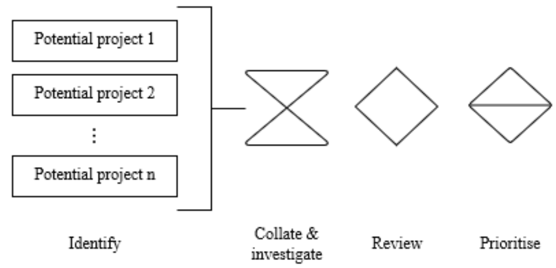

Figure 12. Portfolio Management process

As can be seen in Figure 12, potential development projects are identified, collated and investigated, reviewed and then prioritised. From this prioritisation of potential development projects, resources can be distributed as required. Furthermore, additional investigations can be initiated for those potential development projects that fall short of the required threshold. Brand new potential development projects can also be considered at this stage to increase the chance of identifying viable projects.

To manage multiple potential and actual development projects, Portfolio Management is used. Numerous tools, method and frameworks have been devised that aid in the investigation, evaluation and prioritisation. This is vital when distributing resources to those prospective projects that have the greatest potential. Many existing tools, methods and frameworks commonly focus on monetary attributes or only use a fixed set; those approaches can be very inflexible and not truly reflective of what is important to the particular company. The proposed ABC Threshold approach to Portfolio Management allows for customisation by the company to the attributes that are most important to describe a potential development project. In addition, clear indications as to the development path to follow are given by the use of the threshold approach which can also indicate when additional investigation is required.

However there are several possible considerations related to the ABC Threshold approach. Within a company setting, a system to implement the three methods is required; this would necessitate the correct development and error checking. Secondly, the required data needs storing in a way that is easily collected for utilisation in the scoring methods. Finally, as noted earlier, the set threshold can have a profound impact on the potential developments selected. Therefore the setting of the level is critical and will require careful consideration and potentially trial and error to correctly match the given situation.

In summary, the ABC Threshold approach gives enough flexibility to the company to adopt bespoke Portfolio Management by identifying the attributes that are most important to them for investigation and evaluation whilst being non-subjective, devoid of bias and delivering a true reflection of the company's R&D position via adoption of an appropriate decision threshold value.

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